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and for practical and methodological purposes correlate with physical processes having determinate connections of their own.

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A FUNCTIONAL VIEW OF NATURE AS SEEN BY A BIOLOGIST[1]

THE following outline makes no claim to originality of treatment. It represents merely the attempt of a naturalist without philosophical training to formulate in his own vernacular certain current philosophical views in form suited to the practical requirements of his own scientific thinking. Terms are used as far as possible in the ordinary untechnical sense with no attempt to conform them to the historical usages of metaphysics. The obvious impossibility of eliminating traditional philosophical implications surely need not deter us from the attempt to do so!

We are accustomed to say that all things which constitute the materials of physical science are known to us only through their properties, *i. e.*, their behavior. It would accord more directly with experience to say that the behavior is the thing so far as known. Any substance back of the behavior is a postulate which certainly has not the merit of inductive proof. The new physics and the new chemistry (the boundary between them is breaking down) are coming to dynamic forms of statement, and Ostwald even goes so far as to affirm that the concept of the atom as brute matter is a metaphysical perversion which has exerted a most mischievous depressing influence on the progress of science. And certainly, in the organic realm, the higher we go in the scale the more clearly does function or behavior stand out as the criterion of our definitions.

That things do not exist apart from their function or behavior is a conception which possibly will not commend itself at first blush to students of physical science, though it is one of the fundamentals of biology. Our customary definition of protoplasm as living substance, for example, is a case in point. Dead protoplasm is a contradiction of terms. It ceases to be protoplasm as soon as the distinctively vital modes of function are replaced by others. This is easily recognized because the vital modes are constructive and conservative, while the inorganic modes which replace them upon the death of the organism are destructive agencies, so that a change from one mode to the other is signalized by an obvious change in the static aspect of the thing.

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[1] Read before the Philosophical Club of the Ohio State University, January 16, 1905.

But reflection shows that the same is true of any mechanism, if definitions are pushed to close limits. The function of a watch is to keep time. If it fails in this it is not a watch, though it may have most of the necessary elements of a time-piece. Obviously the mainspring is not the watch, nor is all the rest of the mechanism without the mainspring a watch. The loss of any element essential to the performance of the function of keeping time destroys its value as a watch.

Or, take a simpler illustration. I blow a soap bubble. It drifts past on the breeze, hangs glittering for an instant and bursts. As it poises before me it may be taken as a type of an object. But *what* is it? What does it mean? Its spherical form, quivering iridescence and undulating trajectory—these speak eloquently to the physicist of molar and intermolecular forces in delicate balance and of a long chain of antecedent transformations of energy. Let the balance of these activities be suddenly disturbed at any point in the system, and the object vanishes instantly.[2]

We have no experience of absolutely passive existence. All that we know can be expressed in terms of action and reaction. My brother has stated it in these words: "The energists claim . . . that substantiality is expressed by relation among activities. Activities are positive realities whenever they are shown to belong together. The bringing together is the substantiality sought, and to seek further is illogical. A relation is a real thing and expresses a law of organization. The organization is the organism" ('The Passing of Scientific Materialism,' *Monist,* January, 1905).

It is perhaps conceivable that activities might 'belong together' in perfect frictionless equilibrium. Our experience, however, gives no instance of such a perfect equilibrium; but rather of correlated action and reaction, a continuous disturbance of equilibrium with readjustment.

Our vocabulary contains no single term which designates this essential feature of things. The word *object* implies only the static or inertial aspect. *Action,* on the other hand, as generally used, ignores this aspect. But as a matter of fact all action does present, when viewed in its entirety, the element of reaction, of resistance, of stasis. We know no 'pure energy' in science, and as in the course of this discussion we use the dynamic terms, action, function, behavior, etc., they must be understood as carrying this enlarged connotation.

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[2] James brings out very clearly ('Psychology,' Vol. II., p. 334) the relation between the so-called real essence of things and their properties in these words: "Readers brought up on Popular Science may think that the molecular structure of things is their real essence in an absolute sense, and that water is H–O–H more deeply and truly than it is a solvent of sugar or a slaker of thirst. Not a whit! It is *all* of these things with equal reality, and the only reason why *for the chemist* it is H–O–H primarily, and only secondarily the other things, is that *for his purpose of deduction and compendious definition* the H–O–H aspect of it is the more useful one to bear in mind."

All finite activities, therefore, are of the nature of movement against resistance or under tension. This perfectly general statement is inductively arrived at. It is the most general formula of reality at present possible. This movement is not always of the same mode, or form of energy, and our concepts (and especially our language) are all in terms of single modes, so that the pursuit of the discussion in terms of general formulæ is difficult, if not impossible. Accordingly, we shall frame our statement in terms of one of the simpler modes (mechanics) and endeavor later to illustrate the application of this formula to other types of existence.

Every finite existence may be said to involve a polarizing of being into a focal point or center (which is not fixed, but progressively changing its character and trend) and a *relatively* more fixed field throughout which the energy involved plays (and which to this extent at least must be active). The thing existing is not the focus nor the field, but the total situation.[3]

Things are defined by the character of their manifestations of energy, and this, in turn, is determined by two factors: (1) the intrinsic form or trend of the central or focal factor (determined largely, if not wholly, by past modes) and (2) the extent and character of the field involved, *i. e.,* the nature of the resistance overcome during the movement.

In the nature of the case we can not regard either focus or field as absolutely fixed, but must go back to the ancient doctrine that all things are in a state of flux. But the fluidity is not perfect (*i. e.,* we have nothing in nature corresponding to the metaphysical doctrine of pure being), and the sphere of resistance which any concrete activity meets is its 'field.' From the point of view of this thing the field is relatively fixed, though it may be as labile as you choose when viewed otherwise. So the 'focus' of this activity may lie in the 'field' of some other. The figure, of course, is very gross and must not be pushed far. Perhaps the meaning will come out more clearly in the application to the higher types of beings.

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[3] Nor is it the realizing in my consciousness of the situation. The thing, in one of its aspects, is the modality of energy, and, from another point of view, may be the *form* of experience. Or, more explicitly stated, we take our departure in this inquiry from a realistic standpoint as contrasted with that of subjective idealism.

The situation as thus defined may be looked at in various ways, of which two require more special treatment. (1) It may be viewed in longitudinal section, *i. e.,* as taking place in time. Here the running sequence, the fluidity, brings into strong relief the dynamic elements, and we see the process as *function.* (2) It may be viewed in cross section, *i. e.,* as extended in space. Eliminating the temporal factor, as in an instantaneous photograph, the static elements more clearly appear and we term it an *object,* a *structure.*

It must be noted that the thing under consideration is neither the structure nor the function, though it is both. This distinction does not exist in reality; it is artificially produced in our attempt at analysis. But the artifact is a necessity by reason of the limitations of thought and of language.

It may be objected by the philosophers that in such a methodological analysis of experience as we are here attempting the concepts of time and space are out of place. This may be true, and it is freely admitted that the figures of the longitudinal and cross sections must not be treated as ultimate conceptions. But these concepts of time and space are very useful as tools of scientific research and it must be left to the philosophically inclined to formulate the distinction between function and structure in more general terms. This has been attempted from various dynamic points of view. Thus we have Bawden's expression, 'The function is the meaning of the structure'; Dewey's logical formula, 'Judgment is the direct reference of meaning to existence (predicate to subject): inference is the indirect reference'; and C. L. Herrick's, 'Existence is the affirmation of attribute.' All of which carry us rather too far afield to serve our present purpose.

Our figure suffers from the more obvious defect that any *section,* even the 'longitudinal section of a process,' is necessarily static, so that to bring out the meaning the term must be loosely used for a view of the movement *as movement.* Now, scientific explanation is the putting of things into relation, and the bonds of relationship come out more clearly and in richer detail when attention is fixed on the dynamic phases of the thing than when we look at its structure. But these dynamic phases are often too intricate and evanescent for our imperfect senses to take in. So to bring out clearly the difference between a pacer and a trotter we compare two series of instantaneous photographs of the movements. These, however, can never give us the full explanation until we translate them back into movement either by means of the vitascope or in imagination.

Or, again, the success of the histologist who studies serial sections of the brain of a fish will be measured directly by his ability, not only to carry in mind his enlarged reproduction of the *structure* in the three dimensions of space, but especially to vivify that reconstructed mechanism by functional interpretation. If he stops with the construction of a wax model, he may create a fine work of art, but as a *scientific* product it is worthless until he goes on to discover what each part is *for, i. e.,* what it does.

Beings may be ranked in a graded series (which may correspond approximately with the order of their appearance in time, on a theory of progressive cosmic evolution) on the basis of the form and the elaborateness of the energic complex, their range or the extent of the 'field,' and the definiteness of the polarization of focus from field. Thus a dynamo is a higher type of being than a tuning-fork.

Living beings are exceedingly elaborate complexes in which one of the distinguishing features is the high degree of differentiation of intrinsic and extrinsic factors, of 'focus' and 'field.' The intrinsic factors are illustrated by heredity and all the distinctively vital functions; the extrinsic factors are collectively termed environment (including the internal environment, as well as the external environment). It seems probable that at or near the focal point of the system lies metabolism of proteid. The organism is the interacting system as a whole, *i. e.,* the sum total of the reaction of protoplasm and environment, and may be studied from without, either as static (anatomy) or as function (physiology). In fact, the term *function* was first applied in this sphere, and the current specialization of physiology apart from anatomy is an expression of the importance of this analysis.

We recognize at once the solidarity of inorganic bodies with their environment. All inanimate nature is closely articulated in the perfection of mechanical adjustment. With living bodies the same intimate relation with environment prevails, as suggested by the Spencerian formula, 'Life is the continuous adjustment of internal relations to external relations.' But *in addition* there is a more perfect autonomy which is better brought out in my brother's definition of life, 'The correlation of physical forces *for the conservation of the individual.'* The emphasis here upon the persistence of individuality during change signalizes the distinctive feature of living bodies, and brings out sharply the contrast between focal (individual) and marginal (environmental) peculiarities to which reference was made above.

Man as organism may, of course, be studied in this way. But *my own* being stands opposed to all others in that there is self-consciousness. This, of course, is unanalyzable and inexplicable. But (and this is the essence of the 'functional' philosophy) it is not a thing apart, incapable of correlation with other parts of nature. It, too, is process, and when studied as such is found to have much in common with the dynamic process or function as we find it in the objective study of other things than our own experience.

We have the evidence directly in experience that the conscious process is a movement against resistance, is tensional. A passive experience is an impossibility. We say, 'the mind goes out' actively to every presentation of sense, and the higher types of mentality exhibit tension and the overcoming of resistance at every step. At present, therefore, there is a tendency to regard the doubt, the question, as the typical psychic mode. When the question is answered and the resistance overcome this psychic process comes to an end; we stop thinking about it, though it may immediately become a datum for a new train of thought. Or, if apperception be chosen as the typical psychic mode, it amounts to much the same thing. A mere sensation is meaningless until assimilated to past experience. Until so assimilated it represents merely a break in the continuity of experience. This is unnatural and distressing; hence tension and effort to effect the synthesis. Apperception is the active building of the new element into the previously framed structure, and the questioning process continues until it fits into its place. We have at the end cognition of an *object,* the object as known representing the static phase of the dynamic process which we term cognition.

In this and many other ways which might be cited, consciousness as given directly in experience can be compared with the dynamic aspect or *function* of the other realities of our world. But my conscious life may also be studied critically in retrospect in a scientific way, and the consciousness of other men and lower animals may also be studied through the medium of language and other physical manifestations. And, when thus studied scientifically, consciousness is found to bear all the marks of a physiological function. Viewed physiologically, the relation between brain and mind is similar to that between the dynamo and the electric current which it 'generates' Either is meaningless—indeed, not really existent, as we saw at the beginning—without the other.

In the case of brain, electric generator and soap bubble, to recur to our first illustration, we have a dynamic complex which polarizes into focus and field. Looked at as static and in terms of space relations, we have structure (bubble, machine, brain). Looked at as process and in terms of temporal sequence, we have function.

To an outside observer the relation of structure and function is essentially similar in all of the cases cited. The activity of any brain other than my own (and of my own in some of its processes) I recognize as a function strictly comparable with that of any other organ. My neighbor and my neighbor's dog are both to me bundles of structures and functions. But in my own case I have come to recognize, by the indirect route suggested above, the fact that certain of the modes of the activity of my brain (or rather of my whole organism and the environing field related thereto, to be more accurate) constitute my consciousness.

We have seen that progressive polarization, and consequent individuation, is one of the characteristics of advancing rank in the orders of being. This involves, also, a sharper differentiation in our analysis of structure and function. In the organic realm, as distinguished from the inorganic, this differentiation comes out most clearly; and in the mental, as distinguished from physical or physiological function, the process has been carried so far that mental function as such, *i. e.,* as self-consciousness, while conscious of itself as function and of the analysis of structure and function in the elements of its own field, is not directly conscious of the field of its own activity as one with that activity. Indeed, in the nature of the case it can not be. For, while any element of that field, an 'object of sense,' may be, indeed must be by a reflective mind, analyzed into structure and function, both of which are objective to the observer and whose separation by other than logical analysis is obviously impossible, yet the total energic complex which constitutes my life can not be so analyzed except by one on the outside. If my consciousness is the dynamic aspect or function of that complex, it can not at the same time be the static aspect or the structure. That is, my consciousness can not be the function of a structure and at the same time know that structure as structure.

Thus the subjective comes to be sharply set off from the objective in my experience. This sharp opposition is simply a further elaboration of the individuation of intrinsic factors which we saw above to be a distinctive characteristic of all living beings.

Objection may be raised to this form of statement as a characterization of consciousness as a function which has somehow lost its structure, while our main contention all the way through has been that these two are inseparable. But I insist that it is the exact converse. To the naïve man his own mental life is simply function—nothing more. The ancients located the mental faculties in the heart, bowels, etc., and sometimes regarded the brain as a mere temperature regulator on account of its bloodless and inert appearance after death. By prolonged scientific research we have discovered that the brain is in a true sense the 'organ of mind.' But this does not alter the fact that my own conscious process gives me no *direct* knowledge of cerebral structure, nor of any other structure. Directly, I seem to experience a 'stream of thought' or flow of mental process. But I have learned, as philosopher, to see that this is an incomplete and so incorrect view of the case and that my body is the thinking organ. And so we have *found* a structure for that which at first appeared pure function. Furthermore, we have also now found the philosophical unity underlying that which we all experience as duality—the subject and the object—and now we see why it requires both of these factors to constitute the real self, as James teaches in his spicy chapter on the Consciousness of Self.[4]

This polarization of the self with the function of consciousness at the nodal point is doubtless the reason why we find that a functional point of view gives us a more illuminating insight into nature than does a structural view-point, even though we find at the end of our inquiry that from neither position alone can we get a complete view of reality.

It may not be amiss to emphasize again at this point that that which I call myself, like everything else, is neither structure nor function, neither body nor mind. It is the total situation, the functioning structure, action and reaction in a resisting field. From *my* point of view the field comprises the objects of experience and the focus of the action is my conscious process. To an outsider, however, I am merely one element of his field, an object, which he may view either as structure (my body) or as function (my behavior).

If, then, the total vital equilibrium, including as one of its elements the body-mind interaction, constitutes myself, but I can have *direct* experience of only a portion of one member of the system (*i. e.,* of those functions only which we term conscious), how can I truly follow the ancient injunction, 'know thyself'?

We are taught that scientific introspection is an impossibility, when strictly conceived. We can not fix states of consciousness in order to give them critical study. We can only grasp at them as they flit by and then study their vestiges in memory. In this process the dynamic element is lost. They become static, as truly objects of study as brain cells or chemical reactions. Accordingly, the current psychology of the day is mainly of the type called structural psychology and it is only with great difficulty that this can be translated into terms of genetic, dynamic or functional psychology—and that, apparently, only under the influence of pressure from without, from philosophy, biology, etc. These mental elements, when thus objectified and studied in all of their relations, physiological as well as psychological, are found, as we have seen, to belong in the category of *function*. And now that the recasting of psychology in functional terms is well under way, we are led by this indirect route to the belief that conscious process, as I experience it directly in my own life, is function, even though the corresponding structure in the nature of the case can be known as a whole only indirectly. On the other hand, the dualism of my experience does not reach to an outsider. My mind and my body to him constitute one person in whom structure and function (if the observer were sufficiently master of anatomy, physiology and the cognate sciences), though sharply separated in logical analysis, could be fitted accurately together, mutually ' explaining' each other.

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[4] The error of subjective idealism lies in just this failure to recognize a real structural element in things. We may admit, without laying ourselves open to this reproach, that I know *directly* only the mental (functional) member of the dynamic complex which constitutes myself, *i. e.,* of certain interactions between my hereditary and other endowments ('focus'—the 'I' of James) and my environment (the 'field,' which includes the 'me' of James). For I have excellent inductive evidence of the reality of the objective elements of my own direct experience, as well as of other types of interactions than my experience.

Are we then led back to the position of the old materialists, that thought is produced by the brain as bile is produced by the liver? To this one can give a categorical negative. Thought is not *produced* by the brain, nor is any other function produced by its structure, for that is to imply that the structure can in some way precede its function, the impossibility of which is manifest when we consider that structure can be defined only in terms of function. We students of natural science are apt to conceive of structure as something fundamental and primitive to which functions may in some way be added as a sort of accidental 'property.' Nothing could be more unscientific. And the functional view differs from materialism in that it sharply recognizes this fact, insisting that function in general, and mental function in particular, is in no sense to be conceived as subsidiary to, caused by, or derived from structure.

The philosophical questions as to the nature of ultimate existence do not necessarily enter in this discussion, but we may add a word or two. The functional philosopher may share with the idealists the belief that all things in your world and mine have grown up in our direct experiences. This experience is primary and is our ultimate court of appeal. All our world of objects (including immaterial objects such as ideas and hypothetical objects such as atoms and imponderable ether) is a 'construct.' But this world is real (however imperfect may be our realization of it) and serves as the 'field' in which those activities play, the mode of certain of whose tensional phases constitutes my consciousness.

Throughout the preceding argument we have spoken of all finite existences as polarized and as manifesting a duality, which culminates in the dualism of experience as recognized in philosophy. But it must be emphasized again and again that this is a purely methodological analysis, necessary perhaps only by reason of the limitations of thought. The existence itself is *one* thing, and our analytical procedure must not for an instant be used as a justification for an ultimate dualism in nature. Nor, on the other hand, can we take a monistic position on either one of these methodological foundations alone. One can not be a materialist without giving the structural aspect of our analysis precedence over the functional; nor can one be a pure idealist from this point of view without giving the functional aspect precedence over the structural. But either of these procedures destroys the existence of the thing; for the structure can exist and be defined only in terms of function, and function can not exist dissociated from structure. This applies to everything from the chemical element to the human self. The methodological analysis can have significance only when things are viewed from the outside. In the case of the conscious person the clear analysis into the body and mind appears to have come rather late in human history. And from early Greek philosophy to the present time there has been profitless debate as to which of the artifacts thus produced is the real self. The philosopher, in re-effecting their synthesis, does not return to the uncritical attitude of the child to whom the world is 'a big blooming, buzzing confusion'; but he builds up a world of *correlated* reality which is made possible only by reason of the analysis and synthesis in detail of the successive concrete data of daily life.

Again, to conceive the ultimate being as spontaneous energy may be permissible, but the expression is apt to carry the implication that the energy is 'disembodied,' or free from any structural element. This is not justifiable; for if the structure is simply a static aspect or phase in methodological analysis, it is clear that any equilibrated system of energy must exhibit a structural aspect, if subjected to such an analysis as we have attempted above. As a matter of fact, the feature already noted, that we must polarize these elements in order to discuss them, carries the implication that the concepts should be recast. Let us hope that some time they may be passed into solution and recrystallized in a more practicable form than is at present available. To use Professor Bawden's expression, 'The concepts of structure and function, matter and mind, thing and meaning, must be recast in terms of each other.'

At the conclusion of this argument the question naturally arises, What have we gained? Is not the problem of the meaning of the relation between function and structure as great and as far from solution as the philosophical question of the relation between mind and matter in its original forms? Granted. But, note that we have now one problem, not two, and this is the aim of all scientific investigation, to effect such correlations as will reduce the number of unknown factors. The law of uniformitarianism is the greatest induction of modern science, and the present inquiry is an endeavor to bridge one of the many gaps in the continuity of knowledge that still bar our progress. If mind can be subsumed under the general term function, we are the gainers by just that correlation. We have made one further step in the integration of knowledge. The advantages which follow to philosophy from the taking of this step are being rapidly elaborated in the recent writings of the apostles of the functional school.

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REVIEWS AND ABSTRACTS OF LITERATURE

Species and Varieties, Their Origin by Mutation. Lectures delivered at the University of California by Hugo de Vries. Edited by D. T. MacDougal. Chicago, Open Court Publishing Co. 1905. Pp. xviii + 847.

Since the completion, not more than two years ago, of Professor de Vries's '*Mutationstheorie*,' the appreciation of the importance of his contribution to the theories of the origin of new forms has been rapidly growing. During the summer of 1904, on invitation from the University of California, Professor de Vries delivered a series of lectures at Berkeley which, under the editorship of Dr. D. T. MacDougal, are presented in the volume before us.

The key-note of the whole book is struck in the last of the three statements, printed on one of the fly-leaves. These statements, which make a somewhat dramatic opening to the whole discussion, are as follows: 'The origin of species is a natural phenomenon,' Lamarck; 'The origin of species is an object of inquiry,' Darwin; 'The origin of species is an object of experimental investigation,' de Vries. It is in this matter of experimental investigation, perhaps, that Professor de Vries has made the most important advance and has reawakened the active interest which, despite many able workers and theorizers, had flagged since the time of Darwin. To have brought the question within the field of experimentation has brought, too, the hope that some more definite evidence can be obtained as to the mechanism of the origin of new forms. To Professor de Vries's keen reasoning, his acute observation and above all his accuracy and care of culture methods, is due the new light that he has been able to throw on this most perplexing of all problems. To maintain that his theory is complete in all respects would, of course, be the attitude of an incautious enthusiast, but at least this much can be said, the author has seen and has recorded the springing into existence of new forms of plants of sufficient difference and stability to be regarded as what we are pleased to call new species.

In discussing the origin of these new forms it is necessary to distinguish carefully what is ordinarily meant by a *species* and what should be